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A MONOGRAPH BY

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NEW ZEALAND

LONDON
The Buighleigh Press
1928

This reprint is produced by
Euston Grove Press
20 Elderwood Place
London SE27 0HL United Kingdom
www.eustongrove.com

ISBN: 978-1-906267-05-6 (pbk)

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library.

INTRODUCTION

This paper records what is probably the outstdanding accomplishment of the British Museum's recent expedition to the Gobi Desert under the able leadership of Brigadier-General Sir Cecil Wemyss-Cholmondeley, Bart., of Buighleigh Gables, Hants, Herts, Straffordshire, England, The widespread controversy which has agitated scientific circles of recent years as to the nature and habits, nay, even the very existence, of the remarkable organism which forms the subject of this contribution developed such importance that, at the instance of Sir Cecil Wemyss-Cholmondeley, the British Museum authorized and supported the expedition. The author was honored with an invitation to accept the scientific directorship of the expedition, and was much pleased by the prospect of being able to settle once for all the long-continued controversy, and, if possible, to find confirmation for the views he has so long championed in the face of unremitting and bitter opposition.

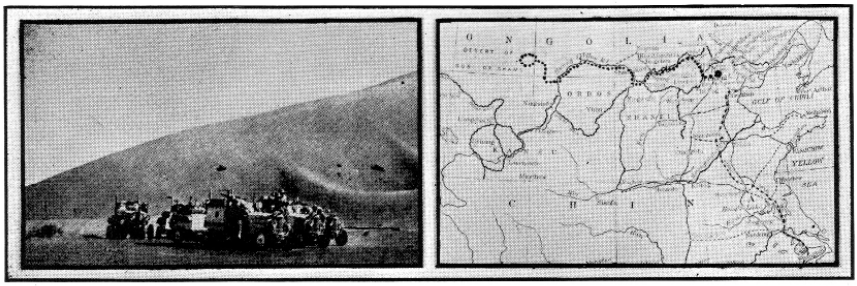

FIG. 1. The motor equipment of the expedition.
FIG. 1. Map of northern China and Mongolia, showing the route of the expedition to the Gobi Desert.

The route followed by the expedition is shown on the accompanying map. The area indicated by the small circle is one never before visited by white men, and not inhabited by natives, due, as we discovered,. to the scarcity of water in the region, and to the presence of a voracious insect pest, *Fugifex pungens,* the Gobi Desert sand-flea. The sanitary arrangements which made possible continued existence and accurate work in such a region are a double credit to the engineering ability of our leader, Sir Cecil Wemyss-Cholmondeley, Bart., and to the expedition's doctor, Professor Angus Laughlin-MacDiarmid, of the John Hopkins University. The expedition found the first specimen in December, 1922, and completed its work in the later part of May, 1926.

That the work was brought to a conclusion without the slightest marring incident or interruption of any sort is due to the unexcelled arrangements and equipment provided by the British Museum, and to the unselfish devotion to their work in the face of disheartening obstacles which was shown by every one of my colleagues. I cannot proceed without publicly acknowledging the deep indebtedness which I personally, and all scientists generally owe to the British Museum and to my zealous colleagues.

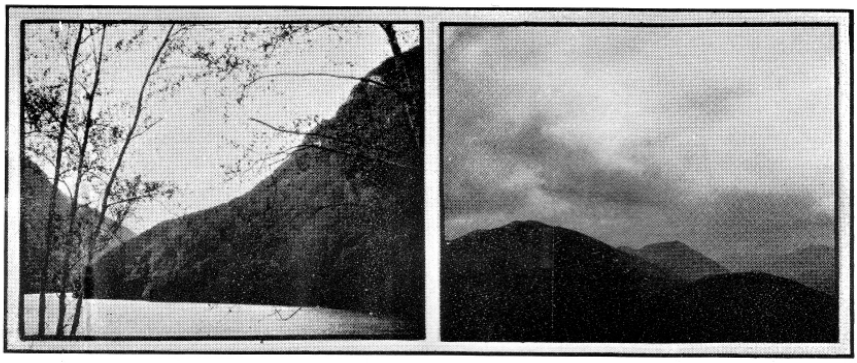

FIG. 3. A mountain lake near the point where the expedition left the Yellow River.
FIG. 4. Barren mountainous country between the Yellow River and the Gobi Desert.

NOMENCLATURE

The name by which the organism has long been known is that given it by Linnaeus[1]: *Micropteron asiatica.* Since Linnaeus definitely states that he did not actually see a specimen, and since he further expressed[2] doubt as to the credibility of reports concerning it, the author has ventured to select as a more appropriate name that suggested in an obscure Persian journal[3] by his esteemed colleagues Francois-Villon and Sugamora, *Eoörnis pterovelox gobiensis.* The chief basis of this selection, it may be pointed out, lies in the fact that unquestioned remains have been found in sedimentary Mesozoic dolomitic silicates, whereas Micropteron is preeminently a genus of living organisms, no fossil remains even remotely allied to it ever having been brought to light. As will appear later, the specific name, *pterovelox,* descriptive of one of the most outstanding characteristics of the organism, is manifestly more appropriate than the nebulous and otherwise objectionable *asiatica.*

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[1] Systema Naturae, 473. Twelfth edition, Stockholm, 1766-68.
[2] Op. cit., 476.
[3] The Teheran Oölogist 7:876-880. 1926.

In addition to the scientific name, mention must be made of an apparently universal native appellation appearing in various forms, of which the commonest is "woofen-poof." This is evidently an onomatopoetic term derived (as we later ascertained) from the peculiar sound made by the bird in alighting. The onlooker's impression is that of two distinct sounds: a "woof" or "whiz" in the air, followed by a "poof" or "shush" made by the bird's feet in striking the loose desert sand.

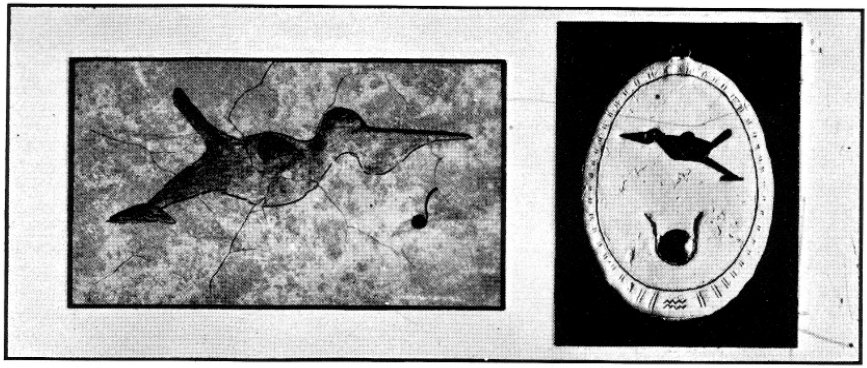

FIG. 5. Painting of *Eoörnis* by a Crô-Magnon artist on the ceiling (now badly cracked) of a rocky cavern in southern France. (After Terrassier, 1912.)

FIG. 6. An amulet found in the tomb of King Tut-ankh-amen and now in the collection of Sir Cecil Wemyss-Cholmondeley. The figure of *Eoörnis* is inlaid in red enamel, and an amethyst represents the eye. Below is the sun disc in gold, with the horns of the sacred bull on either side. The hieroglyph for water in the border at the bottom probably signifies that the woofen-poof once inhabited the Nile valley.

HISTORY

What is probably the earliest reference to *Eoörnis* appears in certain of the Crô-Magnon picture writings found in the caves of the Dordogne in France. These include undoubted representations of the organism in its characteristic resting attitude, invariably accompanied by a symbol hitherto undeciphered, but which is now known to represent music[4].

By an unusual bit of good fortune the expedition returned from the Gobi Desert just as another of England's recent expeditions, namely that to the tomb of Tut-ankh-amen, arrived in Cairo with its magnificent collections. Among the articles discovered in the tomb and placed in the author's hands for study were three amu-

[4] The resemblance of the symbol to that used for the note in modern music is striking, but it seems to the author to be coincidental. The sketch has been taken from the work of M. TERRASSIER: L'Art Ancien. Paris, 1912.

lets, each depicting the bird, again in the peculiar resting pose. The draughtsman ship betrays certain influences of the fellaheen. A symbol usually accompanying the figure appears to be a synthesis of two of the Crô-Magnon music symbols. An interesting field of research and speculation is here opened by consideration of how the circular element came to represent the sun's disc, as all modern Egyptologists agree that it does, and how the note-stems came to represent the horns of the sacred bull. Unfortunately no hieroglyphic reference is found which might explain either the specific use of these amulets or the extent of ancient Egyptian knowledge as to the organism.

A brief reference appears in the memoirs of Eutropius[5]. This Roman historian of the fourth century A.D. remarks that at a banquet in honor of Diocletian upon the occasion of the opening of the baths at Rome the *pièce de résistance* consisted of three strange Chinese birds with long pouched beaks and very small wings, a present from the emperor Hwat Sai. The birds had been preserved in an odoriferous vegetable oil, which, however, served only to enhance the flavor of the roasted morsels. This mention alone would be deemed insufficient, but in the vestibule of the bath there has been uncovered a mosaic showing what is without question an *Eoörnis*. The author has unfortunately been unable to secure a suitable photograph of this highly interesting relic of Roman art, although he has been privileged through the courtesy of Premier Mussolini to examine it minutely.

It would indeed be strange if among the writings of Marco Polo there should not be found some reference to Eoörnis, and in truth this famous traveler gives a very complete description of the bird itself, together with remarks as to its habits which we have been able to confirm *in toto*. He mentions[6] specifically capturing and taming a few young males, noting that they came from the smaller end of a double egg; he also refers to the difficulty experienced in obtaining their customary food. Apparently the females in Marco Polo's experience died soon after hatching. The details given in the passage cited need not be recited here; suffice it to say that they have constituted the chief source of our information about the bird, and certain minor inaccuracies in Marco Polo's other statements have been in part responsible for the doubts cast upon its existence.

Although some mention of the woofen-poof might be expected in the *Historia Animalium* of Conrad Gesner, there appears to be nothing to indicate that this great naturalist was acquainted with the species.

Prior to our present expedition, the most recent record of any authenticity is that

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[5] EUTROPIUS: Book VIII. lines 54-68.

[6] MARCO POLO: II 10.

contained in partly discovered memoirs of Thankgod Pillsbury[7], non-conformist ship's doctor on Captain Cook's ill-fated expedition to the orient. Dr. Pillsbury records the strange effects of the crew's eating eggs obtained from wandering natives and sold as those of the "hoofen-soof"—a delicacy highly esteemed by aboriginal epicures. It would not need the unquestioned similarity of the name to establish the identity of the bird, because Dr. Pillsbury also gives a very complete report of the natives' description, including such convincing details as the musical note while flying and the flexible egg shells.

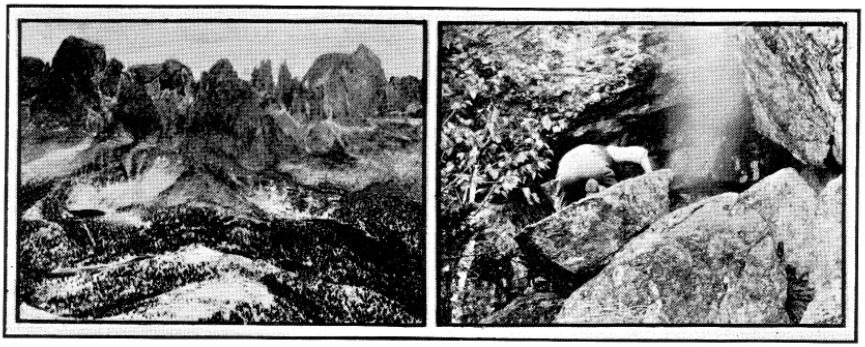


FIG. 7. One of the largest oases of the desert region. Several alkaline pools and large numbers of *Ginkgo* trees are visible. Protection of this oasis from severe dry winds is afforded by the range of high dolomitic pinnacles in the background. The expedition's camp was in a rocky gully near the lower right-hand corner of the picture.

FIG. 8. The author entering the cave which he occupied with Sir Cecil Wemyss-Cholmondeley.

It will be recognized that all of these records are at least fragmentary and incidental in nature. Circumstantial as they are, they cannot be regarded as sufficient to withstand such close scrutiny as modern science demands. At the same time, the repeated references in themselves are too frequent and too much in agreement to permit of any other conclusion than that an organism of this type did exist; and it was in an effort to correlate and evaluate these references, to obtain actual specimens, and to subject these to a critical scientific examination that the present expedition was undertaken.

HABITAT

The only place where *Eoörnis* is now known to live is in the region of the Gobi Desert visited by the expedition. While by far the greater part of this area is arid

[7] PILLSBURY, T.: Memoirs, Book III. London, 1799.

and devoid of all vegetation, there are several large oases. These usually appear as groups of small alkaline pools, in the immediate vicinity of which the chief large plant in *Ginkgo biloba,* a tree of unusual interest to botanists. The surface of the country is far from being flat: in fact it is characterized by a series of rocky sand-strewn ridges, the predominating rock being a sedimentary shale remarkable for the number of amethystene geodes contained, and a dolomitic outcrop which forms in many instances cliffs of heights up to 3000 meters and of imposing grandeur.

The region is subject to extensive changes in temperature, although the prevailing condition is that of great heat. It is also subject to extremely violent cyclonic sandstorms, the most peculiar feature of which is that the direction of rotation is counter-clockwise, exactly opposite to that recorded for similar disturbances elsewhere in the northern hemisphere.

Eoörnis is found throughout this entire area, though the greatest number occur in the sandy desert within 1-5 kilometers of an oasis. Individuals were, however, observed leading an apparently healthy existence on the plateau-like summits of fairly high dolomite cliffs.

DESCRIPTION

In size *Eoörnis* measures approximately 17 cm. from tip of tail to tip of beak, with a maximum wing spread of only 6 cm. The body width is 4 cm., from which it will be seen that the wings measure but 1 cm. each. However, when in the resting position the bird appears to be considerably larger than would be indicated by these figures, owing to the fact that the distance from the tip of the beak to the tip of the feet is about 22 cm. These values are averages of some 2000 measurements, which showed variations from a minimum of 18 cm. (foot to beak measurement) to 27 cm. All measurements were made on adult males and females, the two sexes normally being alike in size. The adult stature, however, is attained rather late. Growth in very young fledglings proceeds more slowly than in most birds, but two or three months after hatching, when the birds become able to cover a wide territory in search of food, more rapid growth soon brings them to adult size.

In color the bird is a sandy brown shading to a paler brown underneath. It is practically invisible against the background of the Gobi Desert sands. The feathers are extremely minute, indeed almost scale-like, resembling the covering of the wings of Lepidoptera perhaps more than anything else. The outward appearance, however, is smooth and glossy because of the presence of enormous numbers of active sebaceous glands on all parts of the body. It is supposed that these glands are a

retention from earlier times when the bird was aquatic in habit. The only change in color which we noted was that exhibited by the female in the breeding season, when for a few weeks she developed bright white and black spots on the breast, body and tail. No similar changes occur in the male.

Perhaps the most outstanding characteristic is the long, stout beak with its pendulous pouch. The beak is of almost the same shade of brown as the feathers. The head if fairly large, and the eyes are markedly protruberant. The neck is extremely short.

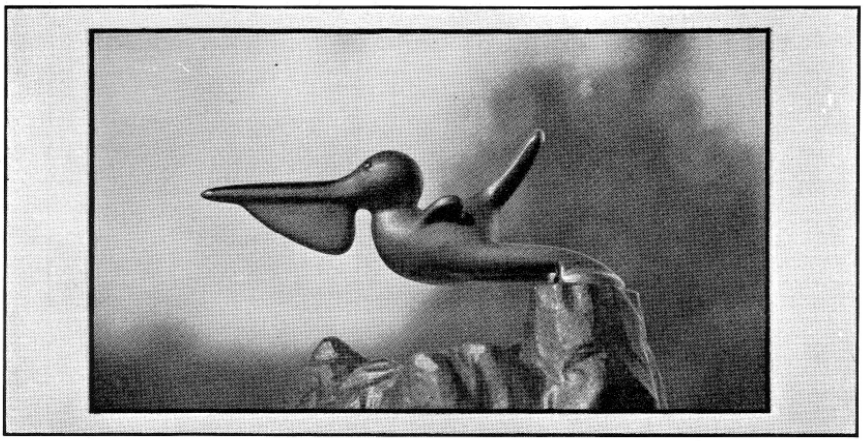


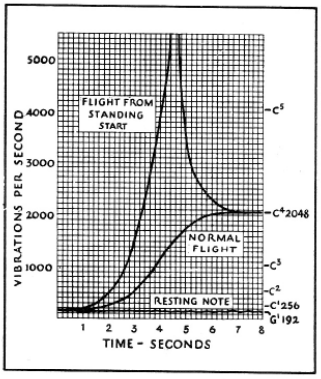
FIG 9. *Eoörnis* resting on a rocky pinnacle, supported by the rapid vibration of the wings.

The wings are almost rudimentary, but are extraordinarily flexible and covered with a smooth sheathing of the same type of fine feathers as cover the body. They are unusual in shape, being roughly semicircular. Due apparently to the almost constant use and the small size of the wings, they are never folded, though there is anatomical evidence to show that in remote ages they must have been capable of being folded.

The tail shows an unusual degree of development, and is characterized by a spoon-like depression on the upper surface. The legs are extremely thick and long, and are feathered all the way down to, and including, the webbed feet. The bird travels on land by means of a curious hopping motion, in which the middle joints of the legs are flexed scarcely at all, while the ankle joints actuate through an angle of nearly 180 degrees. The feet have four toes, one behind and three in front, which are joined by tough webs.

HABITS

The habits of *Eoörnis* are most interesting, and present so many unusual features that it is difficult to know which of these to describe first. The bird is perhaps most frequently observed in the peculiar resting position—legs straight out behind with the feet on a rock, tree branch, or other object, the body being supported by continuous vibration of the wings. The wing-beats in this position are comparatively slow, and make a sound pitched at G below middle C. From the resting position on the ground, flight is started by a series of increasingly rapid hops, the wing-beats increasing in frequency until they emit the normal flying note, which is three octaves



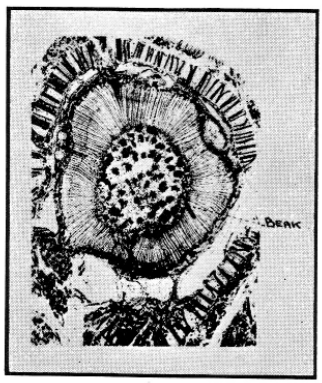


FIG. 10. Graph showing the wing-beat frequencies of *Eoörnis* at rest, in normal flight from the ground and in starting flight from a cliff.

FIG. 11. Section of trunk of *Lyginodendron*, showing the tip of an *Eoörnis* beak in the inner portion of the xylem cylinder.

above middle C. When on a branch or at the edge of a cliff the method of starting flight is slightly different, and involves raising the wing-beat to a frequency so great that to many human ears it is quite inaudible. This is done because the entire work devolves upon the wings, no assistance being possible from the legs. Comparative graphs of the wing-beat sounds in the resting position, in normal flight, and in the moment before commencing flight from a tree are shown in the accompanying diagram. These were obtained by using specially constructed phonographic recorders.

The speed at which the bird flies has been determined to a very fair degree of accuracy. The average of our tests was 414 k.m. per hour. When pursuing a fleeing enemy, however, the speed may be raised to approximately 600 k.m. for brief periods. That this high speed was developed at an early stage in the evolution of

Eoörnis is evidenced by the discovery of the beak of one of the species imbedded in the trunk of a fossil gymnosperm. Petrotome sections showed that the beak had penetrated to a distance of 4.8 c.m. as the result of a collision, and the structure of the wood enabled us to calculate that such penetration indicates a speed of 490.5 k.m. per hour.

It may be interesting to mention briefly the method by which the values for the modern flight speed were determined. The expedition's camp was in a ravine among the lower knolls of an enormous dolomitic upthrust, through which passed a narrow defile or canyon some 1500 meters in depth and with walls almost or quite perpen-

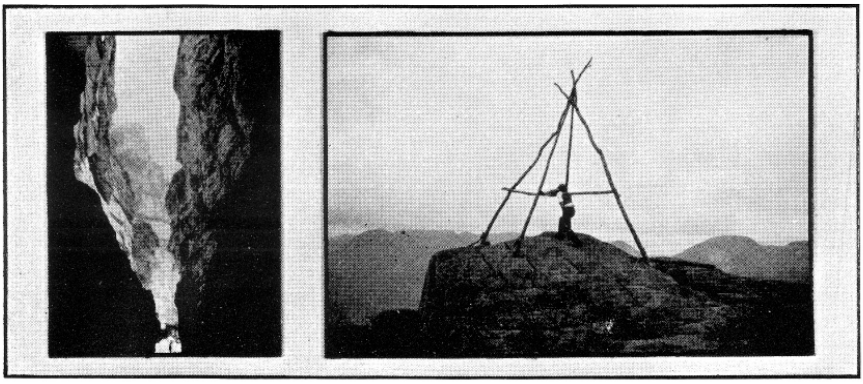


FIG. 12. Canyon through which the birds passed to their feeding grounds.
FIG. 13. The author adjusting a heliographic seleniometer.

dicular. The canyon formed the only convenient passageway between the two favorite feeding grounds of *Eoörnis,* and the birds were in the habit of flying through it almost daily, taking a path approximately level with the upper edge. We later discovered that the reason for the uniformity in the level of their flight lay in the fact that is was the highest altitude the birds were capable of attaining without suffering from changes in the gas content of the colloidal beak fluid due to lowered atmospheric pressure. The birds are gregarious, living, feding and flying in flocks of from 25 to 250 individuals. The flight form customarily assumed by the flock is that of an arrow, which has since been proved to be the original for Sumerian arrowheads. The narrowness of the defile, however, forced a temporary abandonment of this flight form and the assumption of a single-file formation, the individuals being spaced equally with almost absolute precision. By placing two heliographic seleniometers a suitable dis-

tance apart at the edge of the canyon and observing the precise amount of time consumed by any one bird in passing between the two instruments, we were able to calculate the speed directly from a comparison of interruptions in two lines drawn upon a revolving drum in the camp, with which the heliographic seleniometers were in electrical connection. In this manner upward of 25,000 individual observations were made during our stay at the camp, a number far exceeding anything possible by any other means.

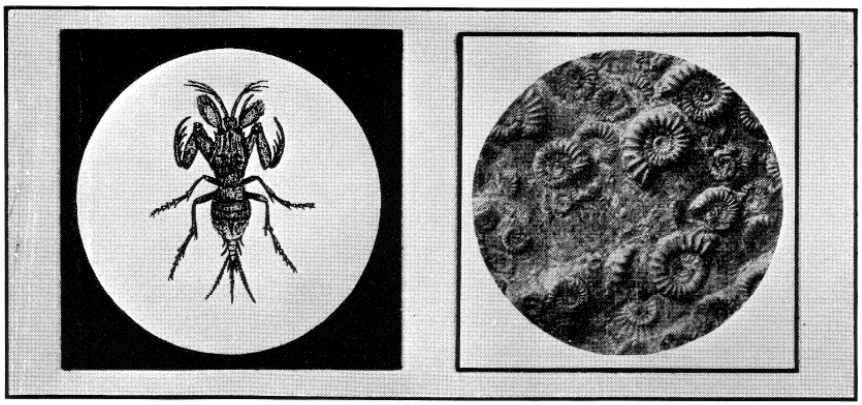


FIG. 14. *Fugifex pungens*, the "Gobi Desert sand-flea," upon which *Eoörnis* mainly subsists. × 4.

FIG. 15. Fossil remains of *Palaeolumbricus dubius*, the worm which formed the principal food of *Eoörnis* in Mesozoic times.

The food of *Eoörnis* is restricted, so far as we were able to observe, to the already well known sand-flea, *Fugifex pungens*, and to the tender shoots and ripe fruits of the maiden-hair tree, *Ginkgo biloba*. A full description of the life habits of the sand-flea is given in the author's recent work[8] on this remarkable insect; and *Ginkgo biloba* has long been familiar to all informed botanists. The enormous numbers of sand-fleas required to furnish nourishment for these birds may be estimated from the fact, ascertained by observers on the expedition, that upwards of 1000 have been found in the crop and stomach of a single bird. At the same time, it has been conclusively demonstrated that the present existence and distribution on this planet of *Ginkgo biloba*, a species which would ere now have disappeared, is due solely to the activities of *Eoörnis* in spreading the seed.

[8] FOTHERINGHAM, A. C.: The life history of *Fugifex pungens*. Cambridge, 1924.

In addition to these two articles of diet, mention must be made of the fact, demonstrated by petrotome sections of fossil specimens, that in earlier times the most frequent article of diet was Crô-Magnon worms, classified by Professor Wilmar von Wurmsmeisel, the leading lumbricologist of Czechoslovakia, as *Palaeolumbricus dubius,* these being the only determinable content of the crops and stomachs. This nocturnal annulate, of course, has long been extinct, but fossil remains are very plentiful in the Gobi Desert embedded in a soft and friable sedimentary rock. A peculiar example of the persistence of instinct is presented in the habit which the modern *Eoörnis* shows of utilizing only the fossil remains of *Palaeolumbricus dubius* as grinding material in the gizzard, a fact attested by countless observations.

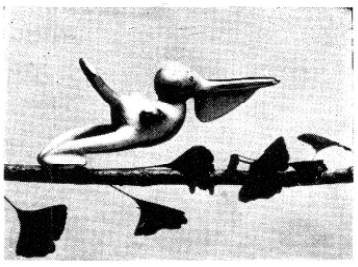
While normally of a pacific temperament, *Eoörnis* is on occasions surprisingly ferocious. When pursuing an enemy, defending its young, or fighting during the mating season it is entirely fearless. The method of fighting is two-fold. Primarily the closed beak is used as a spear, the attack being invariably directed at the eyes of the opponent. The extreme speed of flight in conjunction with a remarkable maneuvaribility makes this method of attack extraordinarily effective. The additional fact that a poisonous fluid is injected into the wound makes the latter all the more serious. No other birds, whatever their size, were ever observed to dispute the passage or other actions of a full grown wofen-poof. In a few cases, however, when hard pressed by an oponent, the bird resorts to a pushing motion of the leg, the power of the blow and the horny under-surface of the foot making this method of attack invincible at short range. The members of the expedition soon learned the customary method of attack, and were forced to wear protective goggles of unbreakable glass during the entire period spent in the desert.

LIFE HISTORY

The mating season occurs in December, in conjunction with the winter solstice. Each female lays but one egg each year, and it was a matter of great surprise to the members of the expedition to note that in regions where only females were present, fertile eggs were nevertheless laid in the same abundance as elsewhere. The observation of isolated captive females and the results of exhaustive cytological studies established beyond a doubt the remarkable fact of parthenogenesis as the explanation of this phenomenon. Although the male is apparently normal in function, his only necessary activity is that of gathering food. The eggs have a flexible, rubber-like shell,

and are obviously double in nature, the shape being that of a bi-globular sphere marked by a more or less pronounced equatorial groove circumscribing the periphery.

The nest consists simply of a collection of the small amethystene geodes which abound in the Gobi Desert, these being pushed together into a shallow depression in the sand. Apparently this habit has been inherited from the distant past, the object being to conceal the eggs by placing them near the geodes which they so closely resemble. This protection is wholly unnecessary under present conditions, but the habit was originally developed at a time when the ancestral arch-enemy, a Triassic reptile, *Lepidosaurus obscuras,* was the chief source of danger to the species. This fact also has been established by the examination of petrotome sections of *Lepidosaurus* stomachs, in which *Eoörnis* eggs and amethystene geodes are almost invari-



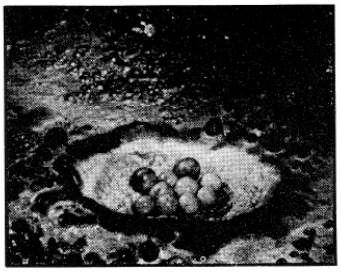


FIG. 16. *Eoörnis* poised on a branch of *Gingko biloba.*

FIG. 17. The nest of the woofen-poof. The uppermost spheroid is an egg; the others are amethystene geodes.

ably found together. This bears out the already well-founded theory that the eyesight of *Lepidosaurus* was none too good. Illustrations of *Lepidosaurus obscuras* and its track are given herewith; unlimited fossil material of this nature is available in the region. Further palaeonotological explorations in the territory immediately surrounding that covered by our expedition would undoubtedly yield results of the highest interest to science.

The eggs require from 165 to 172 days for hatching, provided the weather is normal for the season. Water is necessary for hatching, and this is supplied by rains which usually fall early in May. How many years the eggs retain their ability to hatch is not yet known, but the expedition found several instances of eggs laid a year prior to its arrival which hatched along with others laid in December, 1923. The function of water is to dissolve the hydroxides which are always present in the sand

in which the nest is made, the solution altering the permeability of the tough shell so that it rots away and permits the young birds to emerge. Here is one of the truly unique points in the life cycle: two birds, a male and a female, are produced from each egg. The female is in infancy the larger of the two, althought examination of fossil material shows that this is a coenogenetic character. It may be noted in passing that the most plausible explanation of the great genetic stability of the species—an explanation borne out by exhaustive experiments—lies in the fact that the male and female which mate are derived from the same double egg. This, even apart from partenogenesis, would restrict the variability of the species.

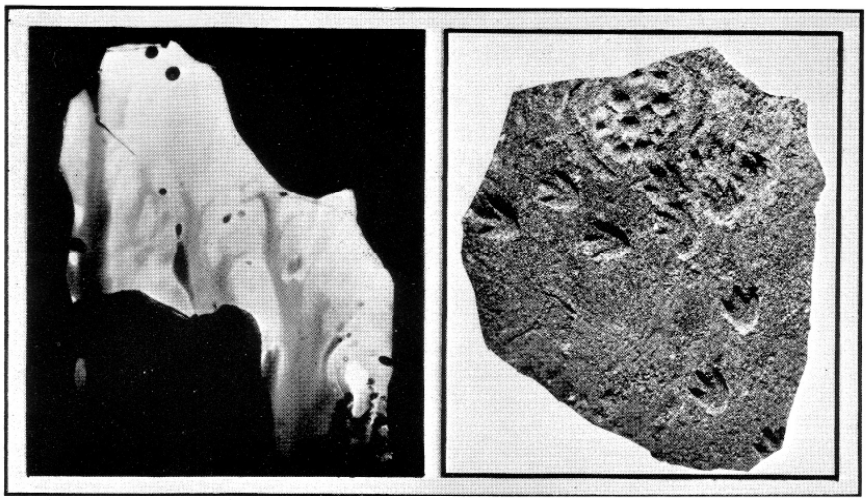


FIG. 18. *Lepidosaurus obscurus.* This fossil, which was found within 300 meters of the camp, shows clearly the toothed jaws, the eye, a portion of the vertebral column, and the peculiar reptilian foot.

FIG. 19. Sandstone slab bearing the tracks of *Lepidosaurus obscurus.* This fossil shows that the reptile robbed the nests of *Eoörnis*, the remains of such a nest being visible at the top. The slab also bears an impresion of a *Ginkgo* leaf (at lower left). × 1/8.

Usually within a quarter of an hour after hatching the mother bird, which, since the advent of the rain, has been waiting anxiously nearby, takes the fledgelings in her beak pouch and carries them to another nest prepared in the upper branches of a *Ginkgo* tree. This nest is little more than a casual agglomeration of sticks, and in many cases a crotch in the limbs serves the purpose. For the first few days after the transfer the fledgelings are fed with a peculiar colloidal gel which occupies the lower

portion, or fundus, of the adult bird's beak pouch. Very shortly, however, the young birds are able to stand by themselves and feed on the tender shoots of the tree. From this time on they are self-supporting and can partake of the fruit as soon as it becomes ripe. In this connection it should be noted that the mother bird always selects an ovulate tree for the deposition of the young. Even the present enemies of *Eoörnis* (monkeys and boa constrictors) have learned this fact, and are never observed to search for the young in staminate specimens.

The young birds are able to fly when they are about two months of age. Just prior to this an interesting function of the male parent or guardian is shown in that the first few fossil worms for their gizzards are brought to them by him. In the earlier stages the young birds are not covered with feathers, but with minute scales exactly similar to those found on *Pterodactylus avioancestricus*. These scales begin to disappear about the third week and ten days later the bird is completely covered with the small thick feathers of the adult. Birds born in May reach sexual maturity the following December.

During the earlier months of the expedition considerable uncertainty existed as to the longevity of *Eoörnis*, until one member of the party suggested the possibility that the vestigial teeth were produced at regular intervals, two pairs each year. This conjecture was later confirmed by observation of captive birds, which rendered determination of age easy and positive. Examination of several hundred specimens showed that the age never exceded 50 years, only one individual of nearly this age (49 yrs.) having been found. Most of the adults examined ranged between 7 and 35 years in age. In this connection it may be pointed out that the most frequent cause of death lay, not as might be expected in muscular senility, but in a deliquescence of the lumbar ganglion resulting in a form of avian Bright's disease.

ANATOMY

Eoörnis exhibits a number of unique and intensely interesting anatomical peculiarities. The beak, composed of very hard chitinized sclerenchyma, preserves on the outer surface a very high polish. Members of the expedition were at a loss to ascribe any function to this feature until the outhor suggested painting the beak with carbon black. It was immediately seen that birds so treated exhibited evidence of serious impairment of eyesight. A study of the eyes then revealed the fact that they are composed of from 50 to 170 tridecagonal prismatic ocelli with anisoangular facets, so arranged that the light rays are received almost entirely by reflection from the beak. This peculiar visual mechanism is correlated with an equally peculiar psychological

feature later to be described, namely, the entire lack of reflex action. While normally protuberant, the eyes are capable of retraction into deep cerebral invaginations, and when retracted are covered by double eyelids actuated horizontally. The vertical slit between these eyelids can be varied at will by the bird, both as to width and divergence from the head's major axis; but it is to be noted that whereas the width of the slit is always the same in the two eyes, the angular divergence of the eyes is independent. The significance of this arrangement is of course to provide proper and varying degrees of light intensity and of angular reflection from the polished surface of the beak.

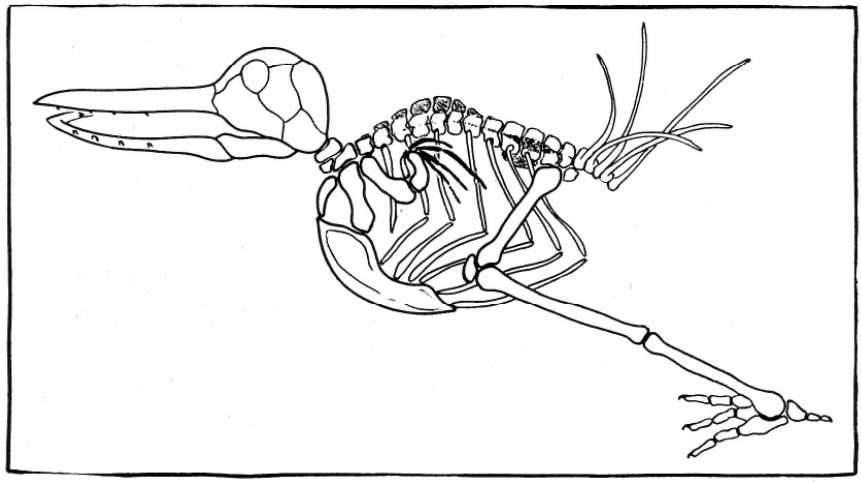


FIG. 20. The skeleton of *Eoörnis* (one side only is shown). Note particularly the dorsal ridge, the finger bones in the wing, and the unique tail support. The positions of the lumbar ganglion and the adrenal gland are indicated.

The most striking skeletal feature is the large dorsal ridge which is made up of horny projections on certain vertebrae, and which serves as an anchor for the supradorsal sheathed wing muscles. After the wing-beat frequency had been determined it was a source of much conjecture on the part of the members of the expedition as to how such a high frequency could be sustained by muscular equipment of the usual avian type. The answer to this puzzle was immediately supplied by an anatomical examination, which showed that the usual wing muscles across the breast are supplemented by two sets of sheathed muscles attached to the dorsal ridge. The sheaths are composed of loose tissue and enclose air pasages which communicate with the

nostrils and the passages in the bones; the function of this air system is probably to cool the rapidly acting muscles. The action of the wings in modern specimens is wholly normal except for the high frequency. Conclusive fossil evidence can be adduced, however, to show that the wing-beat up to early Pleistocene times was alternate; and if additional evidence were necessary, it could be furnished by albino specimens occasionally found. The members of the party were struck by the fact that the flight of albinos is noiseless; and when the phenomenon was closely studied it was found that the wing-beat in such albino birds is alternate, so that the atmospheric vibrations produced by one wing are neutralized by those of the other, no sound, therefore, being emitted.

Equally interesting, though for a different reason, is the character of the wing skeleton. Instead of terminating in the much reduced phalanges of but two or three digits as in ordinary birds, the wing support of the woofen-poof retains all of the bones of at least four digits, as in the pterodactyls of Mesozoic times.

The tail, which we have already mentioned as being concave above, is an appendage admirably adapted to its somewhat special functions. Its most unusual feature is its skeletal support, which consists of a series of prolongations of the last five caudal vertebrae, extending alternately to right and left, so forming a fan-like framework. This fan seems to be homologous with the consolidated pygostyle of other genera of birds. The framework is covered with extremely leathery, flexible tissue from which spring the feathers, the latter, as elsewhere on the body, being very minute. The significance of this unique caudul construction is easily recognized as permitting efficient directional control of the rapid flight. It was frequently found that the under side of the posterior edge of the tail was worn off and entirely devoid of feathers, evidently a result of using the tail as an aid in stopping when alighting on the ground. Modern aeroplane designers have appropriated this feature in the tail skid.

The legs and feet are unusual not only in their length and thickness, but also because of their unique mesotarsal joints, which permit of a range of action of over 170 degrees. Extremely heavy muscles actuate the joints and prevent lateral distortion. Locomotion on the ground is chiefly by hopping with a characteristic vigorous projective thrust from a nearly vertical position.

One peculiarity of the nervous system, which is otherwise like that of modern birds, is worthy of special mention. This is the presence of a large lumbar ganglion

occupying a cavity formed by three or four of the vertebrae. Reference to the functional results of what amounts to a duplex brain equipment will be made later, when we shall also point out the significance of the propinquity of this ganglion and the adrenal gland.

The remaining internal organs require no special mention beyond the fact that the lining of the intestines is covered with innumerable, large, glandular hairs, the exact physiological function of which has not been determined, though it is suspected that their secretion induces the encystment of an endosymbiotic protozoan to be described further on.

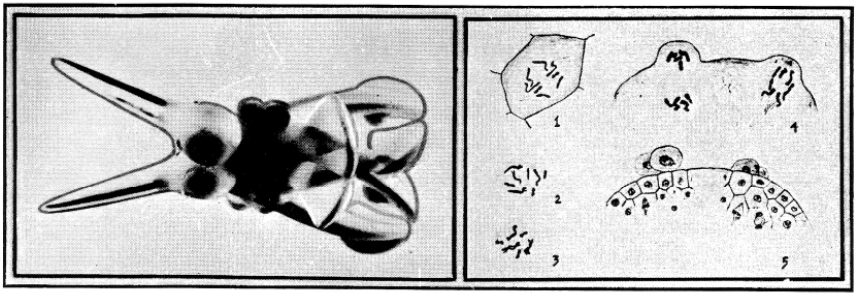


FIG. 21. Conjoined twins formed as the result of a coalescence of the two blastoderms of the double egg. Coalescence in some degree seems to occur in about 13 per cent of the eggs.

FIG. 21. The chromosomes of *Eoörnis*. (1) One of the two nuclei of a somatic cell (in cornea) dividing; 4 chromosomes. (2) Tetraploid nucleus in mitosis; polar view of metaphase, showing 8 chromosomes. (3) Triploid nucleus in mitosis; 6 chromosomes. (4) The two nuclei of the double egg undergoing the first maturation mitosis; early anaphase at right, later stage at left. (5) Two blastoderms developing; binucleate stage not yet reached; polar bodies above. (After Oberstainer und Diener, 1927.)

CYTOLOGY

For my statements concerning the cytology of *Eoörnis* I shall be compelled to rely upon the preliminary account just published with very few illustrations by Oberstainer und Diener[9]. The results reported by these authors are so out of the ordinary that one might easily question their value, were it not for the unimpeachable reputation already established by these talented workers through their researches on cognate problems.

The facts which at present seem well established are these: All of the cells of the adult body are binucleate, with the exception of those in the lumbar ganglion and the adrenal gland, which are uninucleate. The mature egg is binucleate, which

[9] OBERSTAINER UND DIENER: Eoörnisstudien. 1. Zytologie. (Vorl. Mitt. Archiv. der B. E. 1:879, 1927.

will serve to recall our earlier statement to the effect that the egg is double, and hatches two individuals, a male and a female. The two nuclei of the egg take up positions rather far apart and give rise by division to the nuclei of two distinct blastoderms, which in turn develop into two distinct individuals. In some instances these individuals may be joined in various degrees, this being without doubt due to a somewhat closer association of the two original nuclei. The bearing of these phenomena upon the problem of twinning is obvious. It is a noteworthy fact that the blastoderm cells are for a time uninculeate, if one may judge from the single figure so far published. At just what stage the cells become binucleate, and how the change is accomplished, remain to be determined. The presence of a uninucleate phase in the early stages of the embryogeny suggests that this condition is ancestral, and that the binucleate condition has been evolved later for some reason not now apparent.

The authors cited call special attention to the important fact that no reduction in chromosome number occurs in the maturation of the egg, and also to the equally important fact that development is parthenogenetic, as we have already intimated. Both of the egg nuclei are diploid, having two pairs of chromosomes each. The members of one pair are dumb-bell-shaped, and those of the other are strongly suggestive of cranks. It now remains to determine why the two blastoderms, with nuclei of similar chromosomal constitution, develop into embryos different in sex. It is possible that some condition ancestral to the Z W type of sex-chromsome mechanism is present in *Eoörnis,* but it is more probable that a real sex-chromosomal differentiation has not yet progressed very far in this primitive pterovelocic vertebrate, and that sex-differentiation is still almost wholly a matter of metabolism. This is suggested by the fact that the embryo in the smaller end or lobe of the double egg is always male. This hypothesis is now being tested by centrifuge experiments.

It may be observed in passing that normally the two lobes of the egg are nearly equal in size, and that the greater the difference in the size of the lobes, which do vary somewhat, the more unlike the two resulting birds are. It is possible that one factor which has contributed to the preservation of the male is the fact that eggs with decidedly unequal lobes have been destroyed rather regularly by enemies of the species, owing to the less perfect resemblance to the amethystene geodes. Thus eggs with less pronounced irregularities in shape have been naturally selected, and the male has been saved from rapid decline, and possibly from complete disappearance. The ability of parthenogenetic females to survive without aid from males is questionable.

Repeated attempts were made to induce fertilization. Only in two instances were they successful, the birds used being reared in a special laboratory near the summit of the highest dolomite cliff in the region. At high altitudes it is known that the protozoan which lives symbiotically with *Eoörnis* is very scarce, and belongs to a markedly weakened strain. This suggests that the adoption of parthenogenesis by *Eoörnis* may have been causally related to the development of a symbiotic habit. The birds of biparental origin differed from ordinary ones in that they arose only one from an egg, had triploid nuclei, and were hermaphroditic. The cytological phenomena involved here have been only partially cleared up.

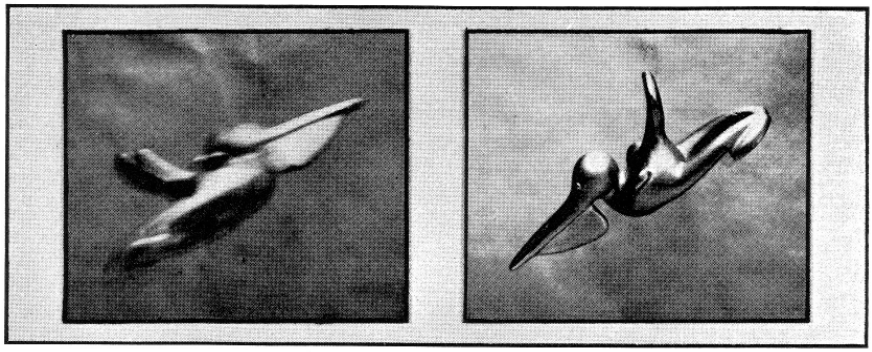


FIG. 23. The woofen-poof in flight. This exposure was made with a shutter working at 1/1000 second.

FIG. 24. The woofen-poof in flight. This photograph was made with the Wemyss-Cholmondeley seleniometric shutter; exposure approximately 1/8900 second. Emulsion used, Mrsicski ultra-green AAA.

Tho mode of origin of occasional tetraploid individuals, which never live more than two days after hatching, is a matter of conjecture only.

It is manifest that the problems raised by *Eoörnis* promise to place this bird beside *Ascaris megalocephala, Lilium Martagon, Drosophila melanogaster* and *Zea Mays* as an object of classic rank in the sciences of cytology and genetics. The sponsors of the expedition have been so impressed with this fact that they have succeeded in having established, in connection with Professor Oberstainer's laboratory in Berlin, a new Biologische Versuchsanstalt für Eoörnisgeschlechtsdifferenzierungskunde. The appearance of fully illustrated accounts of investigations now in progress at the institution is being awaited with intense interest by biologists in all parts of the world. It is hoped that they may be published within a year.

PHYSIOLOGY

In this account limitations of space will permit mention only of the peculiar symbiotic relation which exists between *Eoörnis* and an Asiatic protozoan; except for this feature the physiology of the bird appears to be of the usual avian type.

Because of its morphological features and its relation to *Eoörnis,* this protozoan has been made the type of a new genus, and has been named *Palaeomonoblepharis endosymbiotica* (Hersh.) F. It exists in the encysted state in the wind-blown sands of the Gobi Desert. Although it is frequently found in the motile stage in the alkaline pools of oases, it grows and multiplies most luxuriantly in the beak fluid of

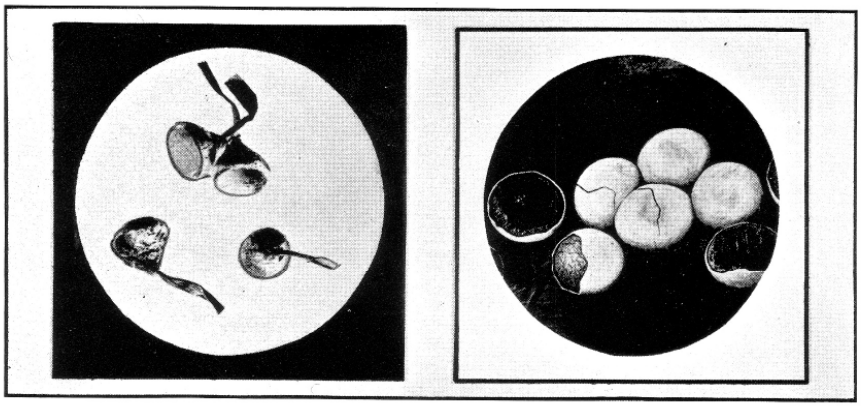


FIG. 25. *Palaeomonoblepharis endosymbiotica* (Hersh.) F. Motile stage. ×900.
FIG. 26. *Palaeomonoblepharis endosymbiotica* (Hersh.) F. Cysts. ×1280.

Eoörnis. Apparently the range of hydrogen-ion concentration which it will endure without encysting is somewhat limited, this range extending from pH 8.0 to pH 11.0.

As the alkalinity increases to the upper limit of this range the motile individuals exhibit a tendency to unite two by two; this is shown in our photograph of *Palaeomonoblepharis* in a medium of pH 10.8. The union is followed immediately by encystment. This onset of sexuality and encystment is clearly an adaptation to the conditions of life in the desert oases, the organism passing into the resistant resting stage whenever the water of the pools evaporates and becomes very alkaline. Of even greater interest is the encystment which occurs as the medium approaches the neutral point. In this case no sexual union takes place, each individual forming a cyst

alone. It seems highly probable in the light of the data presented below that the ability to enter the resting condition in a neutral or acid medium has been specially evolved in connection with the symbiotic mode of life.

An extensive series of determinations of the pH value of the beak fluid from several hundred birds has yielded important evidence bearing upon this question. Except in rare instances this value lies above the neutral point, ranging from about 7.0 to 11.0, or in certain individuals to nearly 12.0. It is found to increase gradually from the time of hatching up to the 9th or 10th year of age, after which it slowly declines. It is rather consistently higher in females than in males. Moreover, when

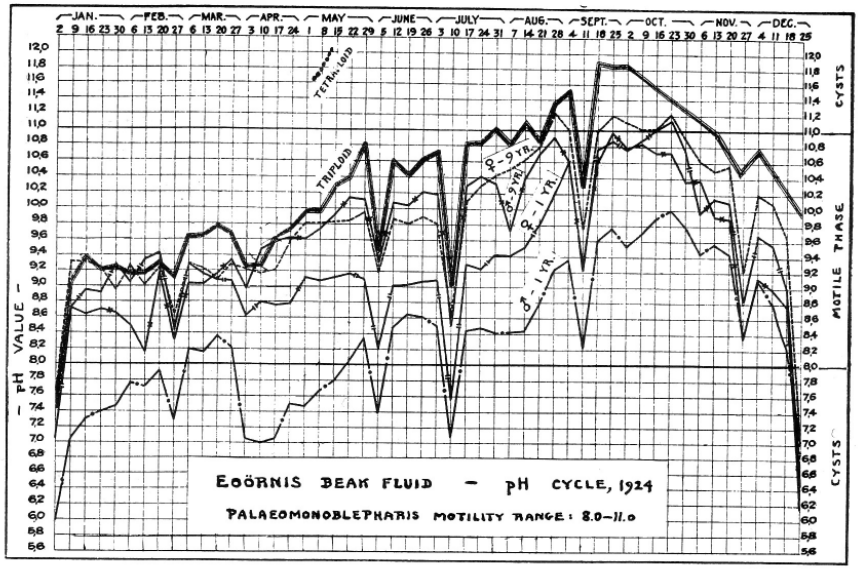


FIG. 27. Graph showing the variations in the hydrogen-ion concentration of *Eoörnis* beak fluid through the course of a year. The symbiotic protozoan remains motile only between pH 8.0 and pH 11.0.

the seasonal variations are plotted they are seen to form a characteristic curve. These facts are summarized in the accompanying simple graph which shows the variations in hydrogen-ion concentration throughout the year for males and females one year old, males and females 9 years old, and triploid hermaphrodites. The values obtained for the highly alkaline beak fluid of the rare tetraploid individuals, in which *Palaeomonoblepharis* shows no growth, are also plotted. It will be noted that during

the late summer and early autumn the concentration in certain classes of individuals may pass out of the range favorable to the motility and active metabolism of the symbiotic protozoan. During this period such birds are forced to draw upon their scanty reserves of fat; in fact, we have frequently noted that triploid individuals exhibit unmistakable evidences of inanition in September. A similar difficulty is encountered by young male birds in the spring, when the reaction of their beak fluids tends to be rather acid. This may be associated with the curios tendency on the part of male birds to imbibe what would seem to be inordinate amounts of the alkaline oasis waters, perhaps in an unconscious effort to restore their metabolic equilibrium. The activities of the mating season are attended by a marked decrease in the alkalinity in all the birds.

It seems that the young bird first obtains its supply of *Palaeomonoblepharis* from the beak fluid of the mother bird. The protozoan remains motile as it passes into the stomach, where it has a profound effect upon digestion; but before leaving the stomach it becomes encysted, probably because of the action of acid secretions from the digestive glands and the glandular hairs lining the intsetine. It is thought that this symbiotic mode of life was developed when the normal diet was composed largely of Crô-Magnon worms. That the bird is still very dependent upon its symbiotic companion is evidenced by the fact that birds raised in pure culture were unable to reproduce, even by parthenogenesis. This, together with the fact that the protozoan cysts require two years of after-ripening under arid conditions before they will germiniate, probably explains why *Eoôrnis* has such a restricted range. An attempt is now being made by one of my colleagues to establish a colony of *Eoörnis* with *Ginkgo* and *Palaeomonoblepharis* in the desert regions of California, where repeated accounts have led us to believe that growth and development will reach a full measure of perfection.

PATHOLOGY

The only pathological conditions so far studied are Bright's disease, already alluded to, and a peculiar diabetic disorder, in which the sugar involved is dextrarotatory in normal birds, and levorotatory in albinos, which latter, as well be pointed out soon, are also left-handed. Moreover, subcutaneous injection of the dextro sugar into a diabetic albino invariably results in rapid and complete recovery, and the corresponding treatment of normal birds with the levo sugar is nearly as successful. Ambidextrous birds have not yet been investigated in this connection.

It may be added parenthetically that the *Ginkgo* trees in the desert area are singularly free from disease; no symptom of any pathological disorder whatsoever was ob-

served. It is not improbable that the ability of the species to resist the invasion of parasites may be considerably increased by its unusual vigor, the chief cause of which we shall point out later; but in view of the results of disease control investigations in certain parts of the world, notably eastern North America, we are strongly inclined to relate the immunity in some measure to the fact that the atmosphere of the region carries in suspension and deposits upon the young plants a considerable amount of almost impalpable alkaline dust. Pathologists will recall an analogous instance in the case of the vineyards in the vicinity of Mt. Etna.

PSYCHOLOGY

The psychological behavior of *Eoörnis* is in many respects very remarkable. In the first place, the species is gregarious and gives evidence of some degree of social organization. Indications of this are seen in the Sumerian arrow form of flight, with the apparent selection of leaders which fly at the head of the arrow; the uniform monogamy; the co-ordinating effect of the vocal note; and the otherwise inexplicable grouping of nests, with corresponding inviolability of property rights.

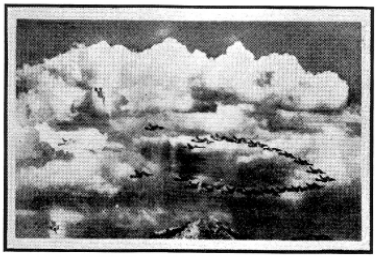


FIG. 28. A comparatively small flock of woofen-poofs flying in the characteristic Sumerian arrow form over the camp. Behind the main group are two birds which have left their companions to alight on the ground, and three others which were observed to take their places in the arrow, spaces being opened to receive them.

The presence of both cerebral and lumbar ganglia gave rise to the surmise that the birds were enabled thereby to reason both a *priori* and *a posteriori,* as has been claimed for the dinosaur and allied species. Confirmation of this surmise was provided in a crucial experiment. A full-grown adult which has been deprived of food for a week was placed between two piles of sand-fleas of exactly equal weight on a level rock in dull weather, so that Illumination was equal on all sides. The bird was placed exactly midway between the piles and facing one of them, care being taken to see that the bird was aware of the presence of both piles. It was the expectation of the author in conducting this experiment that the bird would feed from one pile

or the other, indicating which type of reasoning controlled its action. What was his surprise to find that the two ganglia were of equal functional potential: *a priori* and *a posteriori* reasoning in this artificially controlled environment exactly balanced, and after 7 days of anguished mental struggle the bird died of starvation. It was unable to decide from which pile to eat first.[10]

This experiment, together with countless other observations, also affords conclusive evidence that reflex action is totally absent in *Eoörnis*, a fact of all-pervading significance, and doubtless responsible for the need of symbiotic aids to digestion.

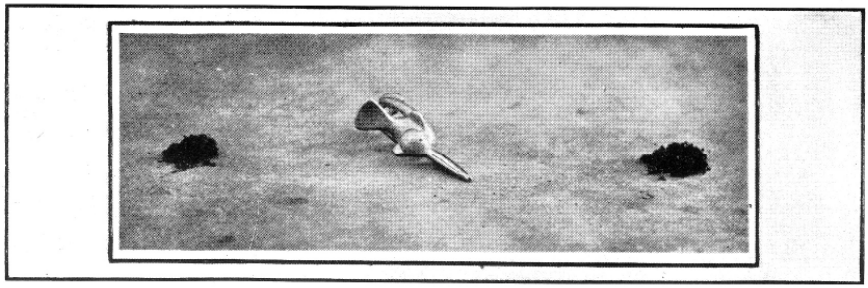


FIG. 29. *Eoörnis* at close of experiment testing the relative functional potential of cerebral and lumbar[11] ganglia.

Reference has already been made to certain peculiarities of albino individuals, to which should be added one of psychological importance, namely, that whereas normal birds exhibit in the use of their feet and in their strong tendency to turn to the right when in flight what corresponds to right-handedness in human beings, albinos are invariably left-handed, if the term may be used; and triploid birds exhibit ambidexterity.[12] The universal failure which has met attempts to rear tetraploid individuals more than 2 days beyond hatching, when the birds show complete functional paralysis, may reasonably be attributed in part to the lethal effect of 4 factors affecting right and left-handedness.

During the mating season some interesting psychological reactions occur. The normal vocal note of the bird may be described as a very low and pure tone entirely free

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[10] This experiment was suggested by the legend according to which Buridan, the 14th century nominalist once remarked that a donkey would starve if placed between two baskets of grain.

[11] First edition read "lumber." Error corrected in second edition.

[12] In view of reptilian affinities to be discussed later, it is appropriate to recall here that the fructivorous ophidian, *Fotheringhamia ambisinuans* Haugh, a non-venomous drupe-serpent found near Lake Baikal, is also known to exhibit right and left-handedness.

from harmonics and somewhat resembling that of the euphonium, being, however, two steps below the lowest obtainable with that instrument. So uniform in all individuals is this tone that it has from time immemorial been the standard for the selective tests of candidates for the bass parts in the imperial chorus of the Chinese court, no candidates unable to reach this note being accepted.[13] It has also been taken as the basis for the series of tuned gongs used in Tibetan lamaseries. The members of the expedition became quite accustomed to the sound of this note, especially at dawn and dusk when the birds were wont to sing. During the mating season, however, it was noted that many variations in the pitch were produced by individual male birds, the difference in the pitch being accompanied by extremely erratic flight involving rapid alterations in altitude. It was soon apparent that a casual relation existed between the flight and the variations in pitch. An exhaustive series of tests revealed the fact that the air over the Gobi Desert is separated horizontally into a series of sharply defined isothermic and isobaric strata. By flying rapidly through these differing layers the male is able with a single vocal note to produce a sort of plaintive melody which gives every evidence of being highly attractive to the female birds.

The unusual suddenness with which the ordinary pacific disposition of *Eoörnis* gives way to the most intense ferocity is thought to be in part explained by the close anatomical association and cytological resemblance of the adrenal gland and the lumbar ganglion, which permit of an instantaneous secretion of adrenalin into the blood stream as soon as the bird inductively reaches the conclusion from its observations that safety requires a demonstration of power. The effect of the presence of adrenalin in the blood upon the emotions as well as upon physical powers is well known to physiologists and psychologists.

So far as we are aware, no investigator had recorded any alteration in the appearance of avain blood upon the addition of adrenalin. It is therefore of more than ordinary interest to mention here what has been observed in *Eoörnis*. The illustration shows two samples of *Eoörnis* blood viewed through a comparison ocular. We may first refer to the unique character of the red corpuscles; these are peculiar in being perforate, a condition not known to exist elsewhere in the animal kingdom. It is possible that this is but the end result of a tendency observed in human red corpuscles, which are biconcave. The perforate condition is doubtless of much psysio-

[13] It is extremely interesting to note in this connection that during the past year a well-known maker of radio reproducers completed careful anatomical, morphological and functional research on the syringeal mechanism of *Eoörnis* and attributes the remarkable success of his latest product in reproducing notes in the lowest registers to the facts revealed by this research.

logical value to *Eoörnis* in that it increases the reacting surface of the corpuscles, and so permits the rapid metabolism necessary in so active an organism. If, now, we compare the blood of a normal bird (left half of illustration) with that of a bird aroused to anger (right half of illustration) we observe that although the leucocytes exhibit no decided differences, the red corpuscles are much deeper in color in the angry individual. That some significant reaction occurs between adrenalin and the pigment of the oxygen-carrying cells is evident, but the precise nature of this interesting relation is at present obscure. It is problems of this character, requiring the closely co-operative effort of cytologist, physiologist and psychologist, that justify the establishment of special *Eoörnis* research institutions such as that at Berlin.

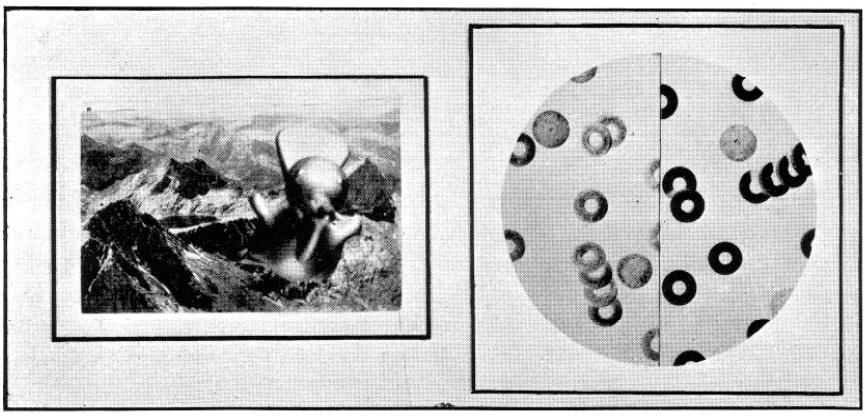


FIG. 30. An angry woofen-poof charging the camera during the taking of a view.

FIG. 31. Two samples of *Eoörnis* blood viewed through a comparison ocular. The color of the perforate red corpuscles is much deeper in an angry bird (right) than in a placid one (left). ×530.

TAXONOMY AND PHYLOGENY

So far as trustworthy evidence indicates, *Eoörnis* is a monotypic genus. When the expedition had arrived in the Gobi Desert and had collected its first score or two of specimens, it appeared not unlikely that these represented several more or less distinct species or varieties. As observations multiplied, however, and as the subsequent cyctological findings were reported, it became evident that the differences exhibited were not of specific or varietal rank, but were due rather to changes in plumage during the mating season and in old age; to certain environmental factors

such as coarseness of sand, which affected the landing sounds; to differences in hydrogen-ion concentration in the water in the oases, which affected the color of the lids of the eye (blue to deep pink); to occasional triploidy, which affects size slightly and is associated in a peculiar way with sex and ambidexterity; and to the varying succulence of the *Ginkgo* fruits available, this factor having a marked effect upon the appetite, weight, and general psychological bearing of the bird, possibly because of the various amounts of butyric acid in fruits of differing succulence. Inbred strains were shown to exhibit all such changes during our stay in the Gobi Desert, which permits of no other conclusion than that *Eoörnis pterovelox gobiensis*

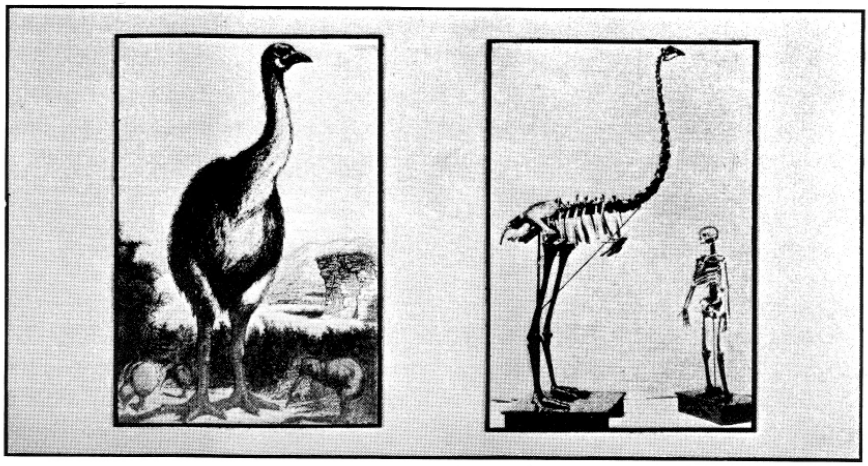


FIG. 32. The moa and the kiwi. (This and the following figure are from Sir E. Arthur Johnson.)
FIG. 33. The skeleton of a moa compared with that of an average man.

is a single species which may show a considerable series of well marked non-heritable variations attributable to fluctuations in the environment factors.

The combination of anatomical and other features characterizing *Eoörnis* is so unique that the genus must be regarded as constituting a single class, the Pterovelocidae. In attempting to determine the relationship of the bird one is at once struck with the clear evidences of Australasian affinities. The frequent use of the leg in fighting and the small size of the wings suggest the ostrich. The famous *Apteryx*, or "kiwi," should doubtless be permitted to claim relationship with *Eoörnis* not only on the basis of the reduction of the wings, in which it has surpassed the latter bird,

having lost them entirely, but also because its chief article of diet is earthworms. The now extinct "moa," of which we present an illustration, was in all probability an ancestor of the kiwi, and stood in the relation of distant avuncularity to the woofen-poof. The beak pouch of *Eoörnis* is somewhat similar to that of the pelican, which is occasionally found in Australia and lived there in large numbers during the Meso-zoic age. It appears not unlikely, therefore, that all of these species have descended from some ancient Australasian avian ancestor, all of them retaining certain features in common, and each developing peculiarities of its own.

Further researches are expected to substantiate the above view. The author is now seeking financial aid for an expedition to the arid regions of central Australia, which have very seldom been explored. Such an expedition should yield important evidence bearing on the origin of southern hemisphere birds; indeed, it is well within the range of possibility that a second member of the primitive genus *Eoörnis* might be found there. If such a new form should be discovered, I venture to suggest in advance that its distinguishing name be *australis*.

As to the affinities of the Pterovelocidae with classes of animals other than birds, there is comparatively little that can be affirmed with confidence. One may be tempted to see in the beak, the webbed feet, and the flat tail evidence of relation-ship with the famous duck-bill, *Ornithorynchus paradoxus,* one of the most curious of Australian denizens. Moreover, the reduced front limbs of the kangaroo, together with the vigorous hopping gait and the habit of carrying young in a pouch, may entitle this animal to a place in *Eoörnis* circle of affinity. Such comparisons should not be pressed too far, but we may be permitted to observe that as investigators of nature we should bear in mind the fact that what is absurd and paradoxical may appear so only because of its unfamiliarity. This is as true of theories as of animals.

Perhaps the least justified of all suggestions is that of the German zoölogist, Pro-fessor Adolf Weilder-Goesser, who assigns great importance to the sense organs in his phylogenetic schemes. He likens the stalked and retractile eyes of *Eoörnis* to those of snails, and is bold to suggest an affinity between birds and molluscs. With this ex-travagant speculation I can have no sympathy; it has the lucidity of ignorance, whence possibly the wide attention it has attracted. In the first place, the eyes of the two classes are only superficially alike; structurally they are widely different, their stalked character affording merely an example of parallel development. Ana-tomical features, important as they are, cannot alone decide such a fundamental question; and I therefore attribute even greater weight to another point of dissmi-

larity, namely, the speed of locomotion. The average speed of *Eoörnis* is hundreds of times that of the swiftest snail known to malacologists; obviously the two animals are not in the same class, nor in closely related classes, from the point of view of either speed or taxonomy.

In agreeable contrast to the immediately preceding phylogenetic considerations, those involving reptilian characters are fraught with the utmost significance, and are worthy of a much more extended discussion than can be devoted to them at this time. No biologist needs to be reminded of the many striking anatomical evidences favoring a fairly close relationship of *Reptilia* and *Aves* and none will fail to recall the manifestations of general interest which attended the announcement of the dis-

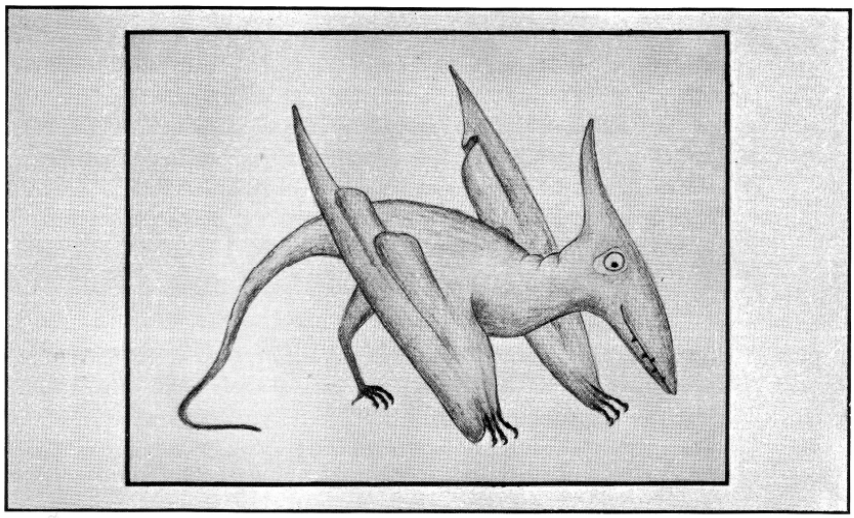


FIG. 34. *Pterodactylus avioancestricus.* Restoration by Wemyss-Cholmondeley.

coveries of *Pterodactylus* and *Archaeopteryx,* two fossil organisms which are generally conceded to constitute "missing links" (to employ a commonly misused but frequently apt expression) between the two great classes in question. There has always been a hope, however, that some fortunate explorer might discover a *living* link of this character. The members of our expedition may with all modesty claim that this good fortune has been theirs. *Eoörnis* is, with no peradventure of a doubt, a living link, and, with *Pterodactylus* and *Archaeopteryx,* proves to all unprejudiced minds that birds have evolved from reptiles.

The confidence with which the foregoing assertion is made has been in large part inspired by a comparison of the anatomical features of *Eoörnis* with those of *Pterodactylus avioancestricus*. Such a comparison has been made possible through the generosity of my colleague, Sir Cecil Wemyss-Cholmondeley, who has placed at my disposal the unpublished results of his prolonged researches on fossil *Reptilia*, and who has contributed the accompanying drawing of his restoration of the species in question. It can safely be affirmed that the anatomical characters of *Pterodactylus avioancestricus*, which are now known more completely and accurately than those of any other Mesozoic animal, not only afford ample justification for the specific name of the organism and all that it implies, but also bring into a clear light the particularly intimate relationship of this pterodactyl and the woofen-poof.

The characters of *Eoörnis* are predominantly avian rather than saurian, so that the organism is much more closely allied to modern birds than either of the other transitional forms. The histologist and embryologist of our expedition, Professor Willem van Kutter, of the University of Groningen, will soon publish a paper setting forth extremely cogent evidence in this connection. I shall therefore content myself with a brief reference to three or four features only, which of themselves should carry conviction.

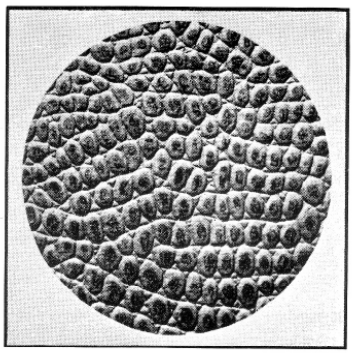
The pronounced dorsal ridge formed by horny projections from certain vertebrae have already been mentioned. This ridge, although it serves in *Eoörnis* as an attachment surface for the strong wing muscles, is shown by embryological study to be the true homologue of the series of erect dorsal plates of *Stegosaurus ungulatus*, the bizarre Jurassic reptile. The special ganglion occupying a cavity in several lumbar vertebrae is also strongly reminiscent of Mesozoic saurians; and it has already been pointed out what an important bearing the presence of this lumbar ganglion has upon the psychology of *Eoörnis*. Modern reptiles, such as the turtle, and modern birds, as for example the domestic fowl, are well known to be very deficient in their powers of inductive thought; and it is of correspondingly great interest to find in a living bird, *Eoörnis*, the retention of an ancient nervous mechanism with attendant psychological proclivities which not only furnish another strong link in the chain connecting *Reptilia* and *Aves*, but which also touch far-reaching questions regarding the evolution of the power of thought.

The teeth may be cited as another pointed argument in favor of reptilian affinity. These valuable tools or weapons occur in reptiles generally, in *Pterodactylus*, the bird-like reptile, in *Archaeopteryx*, the reptile-bird, and in *Eoörnis*. In more modern birds teeth are lacking, except as vestiges in very young parrots.[14] There can remain

[14] I regard as of no scientific value the often quoted proverb which seems to imply that female barnyard fowls may very rarely possess dental protruberances.

no doubt, therefore, that teeth have gradually disappeared in the development of birds from reptiles.

Time permits only the bare mention of two more indications of the reptilian relationship of *Eoörnis,* namely, the scales covering young fledgelings, and the leathery shell of the egg. These are instructive characters, but they are not more so than the details of the development of the embryo, which are to be described by Professor van Kutter in a forthcoming publication.



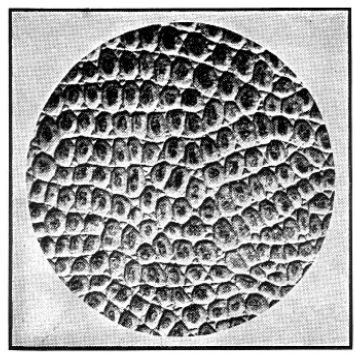


FIG. 35. Photomicrograph of the scale covered skin of a male *Eoörnis* fledgling at the age of two weeks. ×5.

FIG. 36. Photomicrograph of an impression of the scale covered skin on the wing folds of an adult male *Pterodactylus avioancestricus.* ×5.

In concluding these remarks on the relationships, ancient and modern, of *Eoörnis,* I may reaffirm my confidence in the theories of vertebrate evolution which zoölogists have done me the honor to associate with my name, and to add that *Eoörnis* furnishes in support of these theories a series of evidences which I may presume to regard as the most convincing which have as yet come before the attention of science.

SOCIAL AND MORAL SIGNIFICANCE

In concluding this discussion of *Eoörnis* the author feels that it would be a grave omission were he to fail to enumerate some of the more significant aspects of its relationship to human social organization and moral concepts. To regard or interpret biological facts solely in the light of such relationship indicates a confusion of cause and effect and an anthropomorphic viewpoint inexcusable in a true scientist.

On the other hand, to forget that such relationships exist or to ignore them is even one degree more reprehensible, and an error of which scientists have more often been guilty. To obviate the possibility of such an accusation in this case, particular effort was had to see to it that all points at which the bird affected human society were carefully noted and comprehensively studied by the members of the expedition. The more important observations of this nature are outlined herewith.

There seems to be little doubt but that *Eoörnis* was the cause of the extinction of *Lepidosaurus obscurus* long before it could have been brought about by normal environmental factors. Fossil specimens of *L. obscurus* invariably showed geodes in the stomachs and intestines. As there is little likelihood that the digestive juices of even *Lepidosaurus* were capable of rendering geodes assimilable, it is reasonable to conclude that their ingestion caused death. This of itself might be thought a matter of small significance, were it not a fact, well known to scientists, that of all the saurian quadrupeds *Lepidosaurus* was best equipped to meet and master environmental conditions which resulted in the development of *Homo sapiens* from lower primates. Had it not become extinct through the sagacity of *Eoörnis,* who can doubt but that the very advent of man would have been delayed many eons and perhaps never have taken place at all.

Of more recent considerations perhaps the most significant is the well attested fact that a devastating plague of the voracious sand-flea, *Fugifex pungens,* was prevented only by the unremitting activity of *Eoörnis* in gathering them for food and thus preventing their spread. Chinese records, an essential passage from which is shown here, dating approximately 1500 years[15] prior to the beginning of the Christian era, tells us that following several years of particularly favorable climate an incipent plague of stinging insects did occur, but that the gods sent celestial birds, at the express request of the emperor, to consume the insects and thus stamp out the plague. The request was sufficiently urgent to involve the sacrifice of the emperor's son. The descriptions of the insects and of the birds leave no doubt of their identity with *Fugifex* and *Eoörnis.*

Even today the confinement of *Fugifex* to certain regions of the Gobi Desert cannot be accounted for on any other basis than that the presence of *Eoörnis* has prevented its spread elsewhere. Admitting that this is only negative evidence, it is also true that complete studies of the life history and habits of *Fugifex pungens* have

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[15] In a letter to the author Professor Ho Wei-Chang of Peking comments on this MS as follows:

由此字之特性观之足见斯文为古代之手稿

signally failed to reveal any other possible cause, physiological, morphological or ecological. In the author's opinion at least, *Eoörnis* must be credited with the desirable circumscription of the area infested by the insect, an accomplishment of untold importance to the Chinese and perhaps to the entire human race.

Almost exactly opposite is the effect produced in the case of *Ginkgo biloba*. Until very recently, when its beauty of leaf and form has occasioned its artificial culture by men all over the civilized world, this tree was confined entirely to China. Even there, outside the little known oases of the Gobi Desert, it survived only in the temple enclosures under the constant, unremitting care of man—an outstanding biological anachronism, the sole representative of a family whose other members had


ル染色體群デアルトシタ。之ハ兩端
如キ性ニ關係アル三連染色體ガアル
前ニすいばノ染色體ニ就イテ發表
ガ好イ結果ヲ得ズニ居タ。然ルニ著
通ヒ、初メ同所ノ試驗園ニ野生セル
事ヲ知リ、好結果ヲ得タノデ多年ノ
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FIG. 37. Sacred Chinese text referring to the moral significance of *Eoörnis*. This interesting manuscript was discovered in a lamasery in Chunda, Tibet.

FIG. 38. Idol found amid the ruins of an ancient temple near the Yellow River. Near the base of the idol were discovered fragments of a number of small figurines of *Eoörnis*; this indicates the ceremonial use of the bird.

long since vanished from the earth. In the oases, however, *Gingko biloba* has flourished and still flourishes in full vigor without man's assistance, and evidently in complete adjustment to its environment. Specimens 150 feet high were often seen by members of the expedition, and some were of even greater stature. The prevalence and peculiar vigor of the tree about these oases are due solely to the activity of *Eoörnis* in spreading the seeds and in providing in its excreta a fertilizer so much needed by the young *Ginkgo* seedlings. Thus we are indebted to the bird for the continued existence of a beautiful plant fraught for millions of men with all the

associations of their religious beliefs—a plant which otherwise .would centuries ere now have followed the other members of its family into extinction.

Eoörnis, however, has had a far more direct influence on religious and moral concepts than that exerted through the propagation of *Ginkgo biloba.* It was unquestionably the first of higher organisms to develop monogamy, and it even carried this development to the point of parthenogenesis. That this has had a profound effect upon the moral conscience of man, and has led to the acceptance of a monogamous social organization for the human race is a conclusion beyond cavil. References in Chinese literature,[16] in our own Bible[17] and in the Koran[18] indicate that our ancestors observed this and held up the bird as an example of all that was desirable in marital fidelity—an example worthy of emulation by mankind. We now realize that the continued unchanged existence of the organism in the face of cataclysmal environmental alterations is strongly conclusive justification of unusual biological behavior, and marvel anew at the intuitive appreciation with which our ancestors recognized the deep and all embracing importance of the fact.

Finally we come to a point difficult to describe and difficult to evaluate. So little consideration is given to cultural and aesthetic relationships in this age, even by scientists, that one hesistates to mention them with the prominence they really deserve. Through countless ages and successive civilizations this remarkable bird has been the symbol of speed, stamina, grace of line, proportion of members, and beauty of motion. In Crô-Magnon picture writings this appears, in Egyptian hieroglyphs, in Chinese records, in the writings of Tibetan lamas, Bhuddist priests, Arabic scribes and Scholasticists of the middle ages—everywhere appears the same allusion, sometimes in writing only, more often supported with illustrations, these being executed with various degrees of proficiency, but all incontrovertibly *Eoörnis.* Today we see it in the well known willow pattern chinaware, in the stream-line design of our automobile bodies, and in such everyday expressions as "as graceful as a bird." These, perhaps, are small matters in the eyes of most men, but to those of discernment they loom large in the significance of their relationship to human thought and development, and indicate, more than any other facts, the degree to which this little known organism, *Eoörnis pterovelox gobiensis,* has become part and parcel of the cultural and moral heritage of our race.

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[16] Analects of Confucius.
[17] Revelations 23. (Omitted from the King James version).
[18] VII, II.

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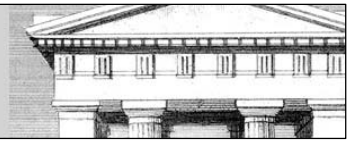

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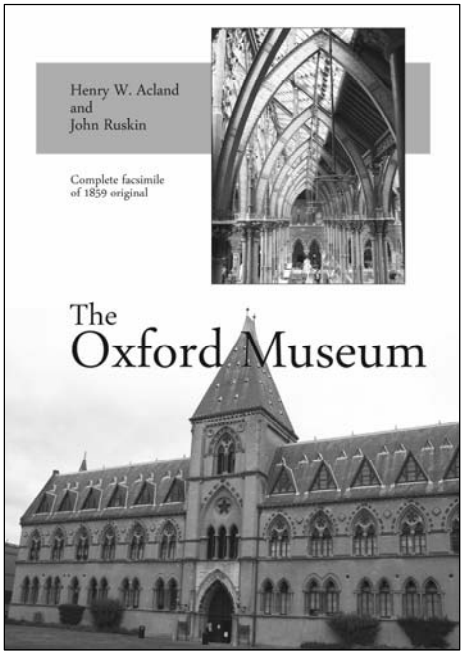

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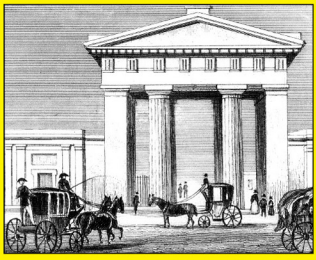

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